DIMENSIONS

The magazine of the National Bureau of Standards U.S. Department of Commerce

November 1978

DISCOVERING THE PAST WITH NEUTRONS. See Page 8.

COMMENT

TO OUR READERS

A printing paper shortage that began several months ago has finally "caught up" with DIMENSIONS/NBS. This shortage is causing publication delays as supplies dwindle. Unfortunately, the paper stock regularly used in DIMENSIONS—selected because it preserves the fine details present in some of our technical illustrations without the glare commonly associated with glossy papers—is becoming difficult to obtain. For the present, we are reducing the number of pages per issue in an effort to maintain use of this stock. Also, we may have to omit the yearly index from our December issue. (If so, it will be printed separately and distributed to subscribers.)

At press time, word is that "no relief is in sight" as far as the paper shortage is concerned. We ask your patience until we are able to resume normal operations.

Juli Chappell

Juli Chappell
Editor, DIMENSIONS/NBS

DIMENSIONS NBS

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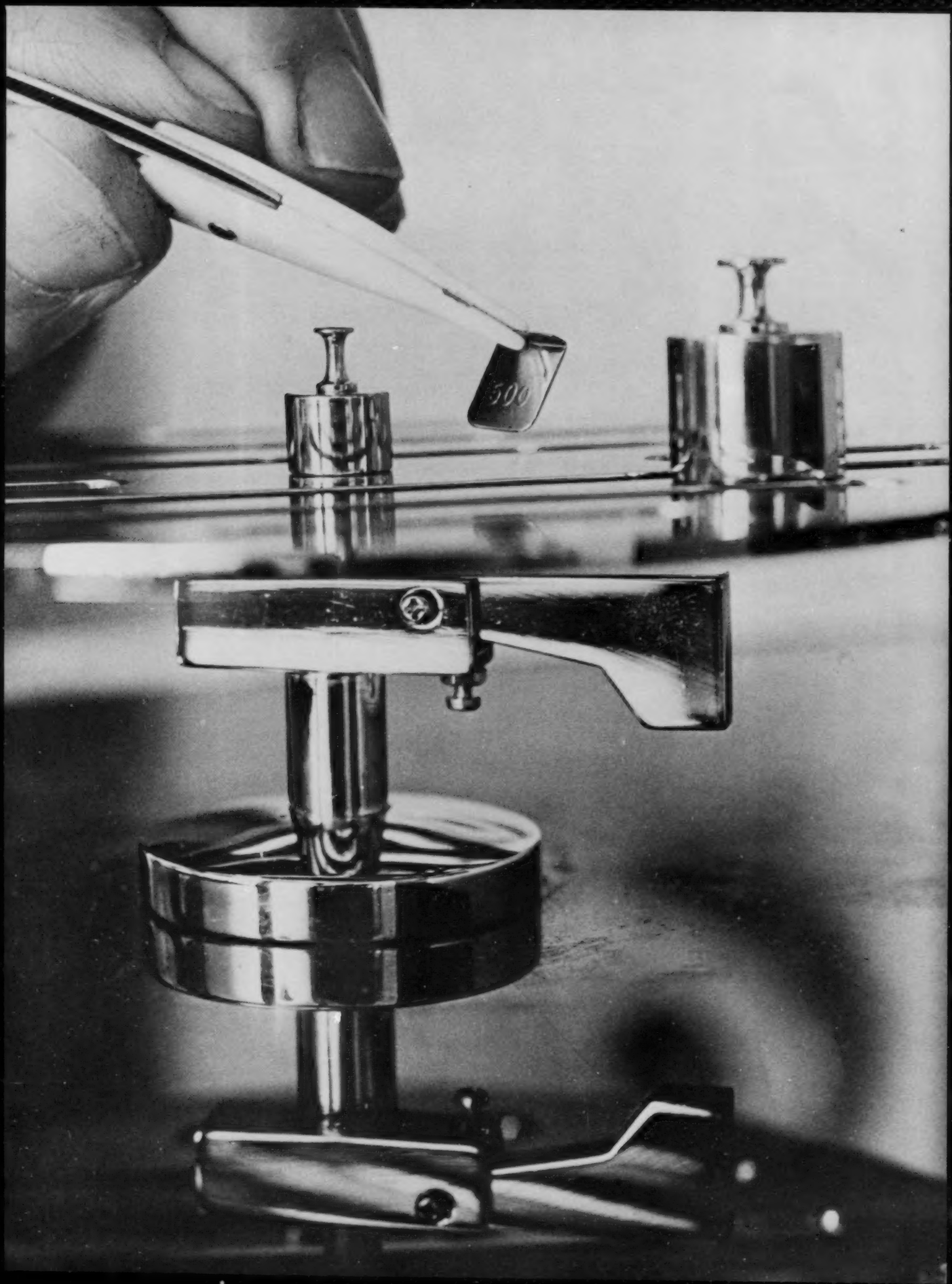
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"Ye shall do no unrighteousness in judgement in meteyard, in weight, or in measure.

"Just balances, just weights, a just ephah, and a just hin shall ye have: I am the Lord your God which brought you out of the land of Egypt."

Leviticus 19: 35,36

". . . a complete set of all weights and measures [shall] be delivered to the governor of each State in the Union . . . to the end that a uniform standard of weights and measures may be established throughout the United States."

Resolution of the United States Congress, 1836

For Good Measure

In keeping with the will of the United States Congress—and possibly even a higher will—every State and territory has new and comparable standards of weights and measures, compliments of the National Bureau of Standards.

If this news is something less than earthshaking, that fact is also a compliment. It is a compliment to the many people at all levels of government from the "Feds" to the grassroots who make a decentralized system of weights and measures regulation work unobtrusively and well. In fact, when Puerto Rico and the Virgin Islands last month dedicated new weights and measures laboratories, these events opened a new era for this, the oldest and most fundamental form of consumer protection.

The two dedications completed a 13-year program to establish working weights and measures laboratories with uniform and accurate standards in all of the 53 States and territories. The completion of this NBS State Standards Program marks an achievement envisioned by our founding fathers 202 years ago. After two centuries of national growth, the United States can truly say it has "uniform" standards for weighing and measuring from ocean to ocean.

With these new standards and functioning laboratories, the States and territories are better equipped to deal with a marketplace that grows technically more sophisticated each year. Unlike most nations, the United States does not exercise weights and measures control at the national level. While a clause in the Constitution delegates authority to Congress to "fix the standard of weights and measures," the Federal Government has generally left the business of regulating weights and measures

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practices to the States. Consequently, there are more than 700 independent or semi-independent weights and measures jurisdictions in the U.S., including State, local, and city offices.

In about one-half of the States, all testing and inspection of grocery scales, gasoline pumps, taximeters, and other commercial measuring equipment are done by State officials. In most cases, the weights and measures operations are part of the State Department of Agriculture since agriculture was the first area in which the accurate weighing of products was a necessity of fair trade.

Most of the remaining States have laws providing for testing and inspection by both State and local officials, with State officials having supervisory control over the individual jurisdictions. However, a few States such as California have State laws requiring that all testing and inspection of measurement services be done by local officials. In California, the state provides specific legal requirements, calibration of field standards, and training of inspectors; the county officials exercise enforcement duties.

The Federal Government didn't get involved in weights and measures until 1836 when Congress, faced with wide variation in measurement standards used in custom houses, created a tiny 3-person Office of Weights and Measures and told it to bring some degree of uniformity to the Nation. Since 1901, the year the National Bureau of Standards was established, this office has been part of NBS.

Using an electronic stop watch and a tachometer, OWM engineer Stephen Hasko checks the accuracy of a new type of digital taximeter during prototype examination.

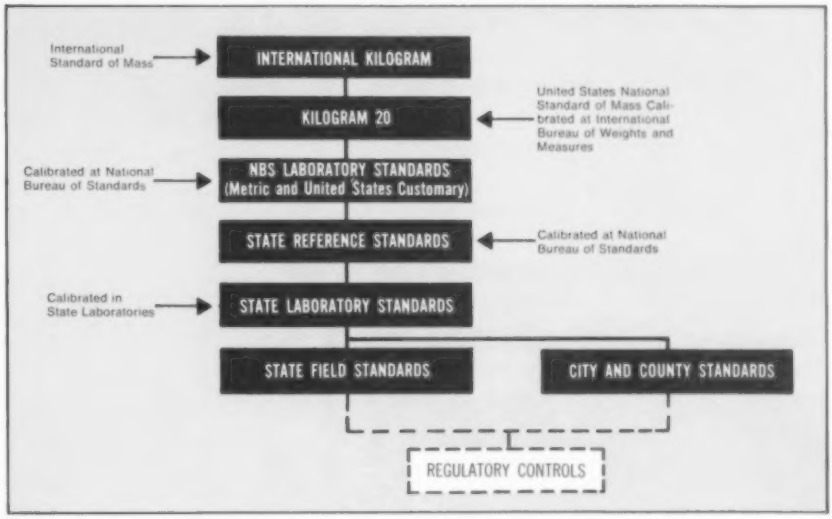
From the beginning, the Office of Weights and Measures has faced a hefty challenge. As mentioned earlier, in 1836 Congress passed a resolution providing for the presentation of standard weights and measures to each of the States. By 1856 all then-existing States had received their standards, and provisions were made to provide new States with standards as each joined the Union. When an 1866 act of Congress officially acknowledged the metric system as a legal system of units, the Office of Weights and Measures also dutifully provided the States with standard metric weights and measuring devices.

But it wasn't until the early 1900's with the creation of the National Bureau of Standards that someone actually checked up on the system of weights and measures regulation to see how well it was working. The Industrial Revolution, large-scale packaging of products, technological advances such as automobiles, and the widespread use of electricity had created new demands for measurement accuracy and uniformity of measurement practices.

In 1914, Louis Fischer, then chief of the NBS Office of Weights and Measures, wrote, "While almost anyone will admit the necessity and the importance of regulation if his attention is brought to this matter, it is a singular fact that it is only recently that any general interest has been manifested in the subject or that there has been any organized movement to improve and enforce the laws in regard to weights and measures."

In a tour of 184 cities and towns 13 years earlier, Fischer noted that nearly 45 percent of the scales tested by NBS inspectors were in error by more than 3 percent. This small percentage, he said, could add up to thousands of lost dollars. Most of this inaccuracy Fischer attributed to corrupt practices of the times. Because local inspectors were paid according to the number of scales they sealed or approved, they were usually more concerned with numbers than with accuracy or proper use. In one instance, Fischer related, he called on a sealer in New York at 10 a.m. and found him still in bed while his young child played on the floor with his set of standard weights and measures.

In an effort to bring order to the weights and measures chaos, Samuel W. Stratton, the first director of NBS, called a conference of State sealers in 1905. The idea behind the meeting was to provide



Each of the standard weights used to regulate commerce at the State and local level is traceable to the International Kilogram housed at the International Bureau of Weights and Measures in Sèvres, France.

National Conference

Speaking to the 63rd National Conference on Weights and Measures, Esther Peterson, Special Assistant to the President for Consumer Affairs, outlines President Carter's efforts to increase consumer representation throughout the Federal Government.

The National Conference on Weights and Measures, initiated and sponsored by the National Bureau of Standards since 1906, is the prime means by which uniform weights and measures legislation is promoted in the United States. Federal, State, and local weights and measures officials and business, industry, and consumer representatives meet each year in July to discuss issues in the weights and measures field and to vote on Model State Legislation, technical specifications, and tolerances for measuring devices. The model State laws and regulations are packages recommended for adoption by individual States or by local weights and measures jurisdictions.

Highlighting the 63rd National Conference on Weights and Measures held from July 9 to 14, 1978, in Washington, D.C., was the amendment of the Model State Packaging and Labeling Act to include instructions for metric labeling. While the revised model regulation does not require the use of metric-only labels, it does provide guidance for manufacturers who want to show metric equivalents on their products.

According to Harold Wollin, assistant chief of the NBS Office of Weights and Measures and executive secretary of the conference, this was the first time that model legislation was adopted through a bicameral system of voting. In order to better represent each State, the conference voting process has been split into a House of State Representatives (where each State is allowed one vote) and a House of Delegates, which consists of the rest of the voting members of the conference. Now, rather than passing with a simple majority vote of all members, a motion must win a majority from both the House of State Representatives and the House of Delegates in order to pass.

The conference theme, "Changing Dimensions and Directions in Measurement Assurance," referred to several of the major topics discussed.

The growing problem of electromagnetic interference or "pollution" and its effects on the performance of new computerized measurement technologies such as electronic scales was discussed by Charles Miller of the National Bureau of Standards and Frederick L. Platt of the Revere Corporation of America. A guide for field test procedures developed by the Scale Manufacturers Association was reviewed and recommended as a voluntary standard by the conference.

In addition, both Ernest Ambler, director of NBS and president of the conference, and Arthur McCoubrey, NBS associate director for measurement services of the National Measurement Laboratory, addressed the topic of expanding regional capabilities for measurement services necessary to regulation and industrial technology. Such regional capabilities might coordinate and combine the resources of several States and provide services in additional areas such as pressure, temperature, electricity, ionizing radiation, electromagnetic radiation, and so on.

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a forum for State weights and measures officials to agree on uniform measurement practices. Since then, the continued growth of industry and the expansion of all forms of commerce have demanded even greater improvements in weighing and measuring regulations. An annual National Conference on Weights and Measures that evolved from the 1905 meeting has served as a major element in the promotion of uniformity based on the consensus of responsible State officials.

Today, a customer who buys a bottle of milk at the supermarket or a loaf of bread at the corner grocery store rarely thinks twice about whether the quantity printed on the label is actually contained in the package. Consumers don't have to be on guard because weights and measures officials are.

Scales, gasoline pumps, milk bottles, taximeters, water meters, and other devices used to measure a product in the marketplace are now tested by inspectors on the State or local level, usually according to specifications and tolerances adopted from Model State Laws.

Model State Legislation is one of the products of the yearly National Conference on Weights and Measures, which brings together weights and measures officials from Federal, State, and local governments and representatives from industry and consumer organizations throughout the country. As an alternative to strong Federal control, the conference adopts model laws and regulations which can then be incorporated into the laws of individual States and localities and enforced at the State and local levels.

Still, the system is a voluntary one, and not all States which have used the Model State Legislation adopt the total package of regulations. Despite great improvements in weighing and measuring practices since the first of these conferences, the States have varied considerably in their attention to enforcement. Prior to the NBS Standards Program, some had not used their original reference weights and measures standards in years, while others had buried them in closets or lost them altogether.

Unlike the last nationwide distribution of State standards in the 1800's, the new standards were delivered under the stipulation that the standards be kept in a modern laboratory capable of meeting some minimum requirements for their proper use.

The sets of standard weights and measures which have been distributed over the past 13 years are made of stainless steel, and each is of a specified weight, length, or volume, in accordance with the national reference standards maintained at NBS. The NBS master standards, in turn, are in accordance with the international standards kept at the International Bureau of Weights and Measures in Sèvres, France (see chart).

Now that each State has reference standards calibrated against the national reference standards at NBS, each can provide more accurate field standards to be used by inspectors on the job. These field standards must be accurate to one part in ten thousand.

Using field standards for weight, length, and volume, State or local inspectors will typically arrive unannounced at a place of business and begin testing equipment used for commercial scales. If a scale, for example, is found to weigh "heavy," the owner is given a specific amount of time to have it repaired. If the owner fails to repair the device within the alloted time, the inspector can, depending on the specific laws of that State, bring legal action to correct the problem. The procedures and severity of fines for inaccurate equipment also vary depending on the State in question.

"Most of the State enforcement programs are in areas where the customer has no recourse," says NBS metrologist Henry Opperman. It is easy enough, he explains, for the consumer to measure a package of string with a ruler to see if it contains the specified length, but not quite as convenient to check the accuracy of the pumps at the local gas station.

Changes in the technology of weighing and measuring equipment can require changes in testing methods or new methods. The recent increase in the use of electronics, for example, has caused a surge in the use of digital scales and other automated point-of-sale equipment. Such devices may be affected by electromagnetic radiation in the area where the scale is to be used. At the request of OWM, NBS technical experts in the Center for Electronics and Electrical Engineering are researching this phenomenon so that in the future, recom-

mendations can be made to the National Conference to amend the *NBS Handbook 44 on Specifications, Tolerances, and Other Technical Requirements for Commercial Weighing and Measuring Devices.*

The Office of Weights and Measures also provides assistance to manufacturers and the States in the form of prototype examination. Manufacturers who have designed new measuring devices may send a prototype to NBS for examination with respect to the requirements of Handbook 44. With the advice of the weights and measures expert, desirable or necessary modifications may be considered before selling the device.

And since the Metric Conversion Act of 1975, the Office of Weights and Measures has been assisting the States in looking out for the consumer as product sizes are gradually being converted to metric. When using both metric and customary units, says NBS Metric Coordinator Jeffrey Odom, it will be important that manufacturers round off numbers uniformly so that no confusion or difficulty occurs. In an effort to speed the voluntary conversion to metric units, this year's conference passed a new version of the Model State Packaging and Labeling Regulation to accommodate metric labeling. (See insert on conference.)

Traditionally, the programs coordinated through the Office of Weights and Measures have been designed to promote equity in the marketplace of retail trade. With the completion of the State Standards Program of 1965-1978, Albert Tholen, chief of the Office of Weights and Measures, is looking toward the future needs for increasing measurement assurance in the areas of industrial and regulatory measurements.

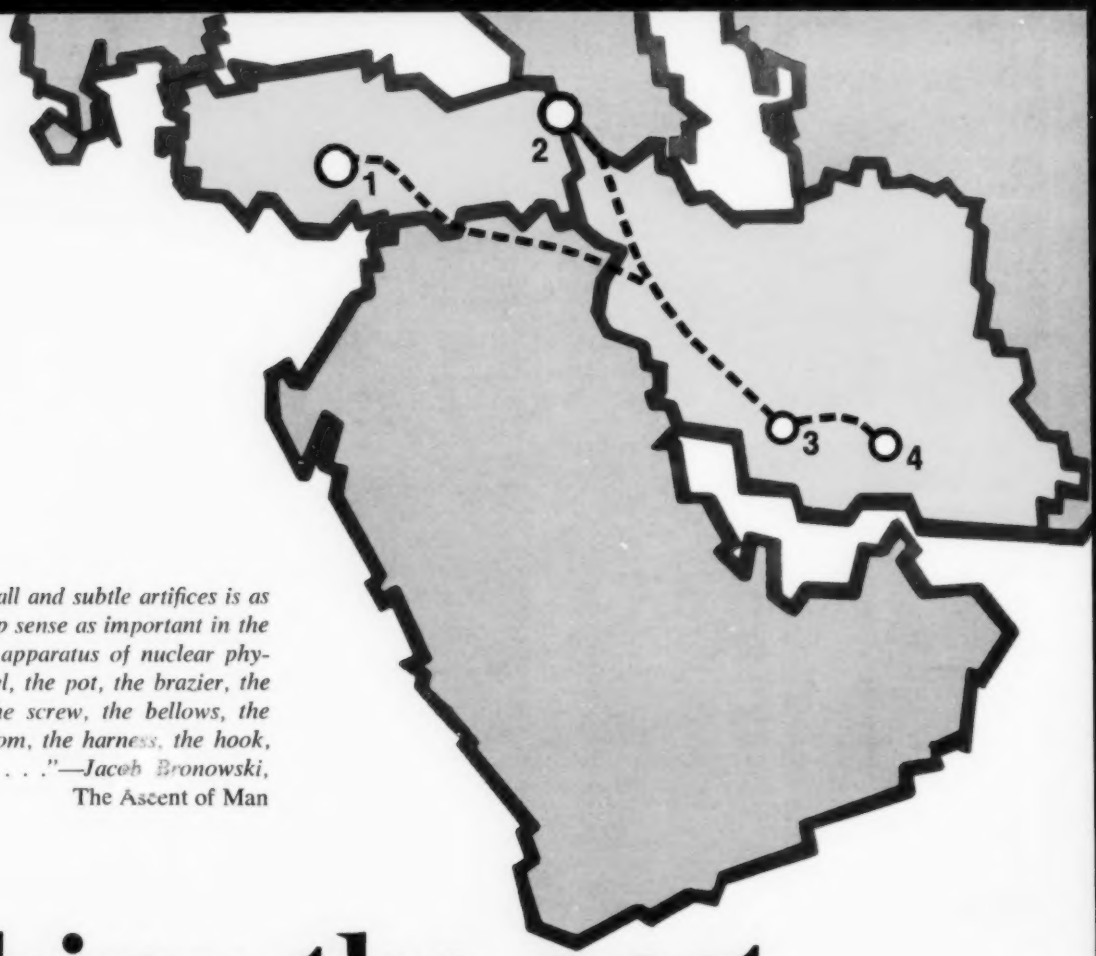
Examples of the types of measurements needed by industries include pressure and temperature measurements for the manufacture of chemicals or hydraulic equipment. Hospitals also need accurate instruments for measuring a patient's temperature or blood pressure. In addition, regulatory agencies which deal with health, public safety, or environmental protection need more instruments and standards which are traceable to national standards to insure laws are enforced uniformly.

Right now the channels of traceability to NBS for industries and State regulatory agencies which must make accurate measurements are not sufficient. In most cases, these organizations must come directly to the NBS for services. A more efficient system, says Arthur McCoubrey, associate director for measurement services of the NBS National Measurement Laboratory, would be for the State metrology laboratories to expand their capabilities.

Albert Tholen, chief of the NBS Office of Weights and Measures, discusses an on-going project with Carol Brickenkamp, project manager for research and development.

"There is no reason to believe all the States should have to have all of the measurement capabilities required by industries," says McCoubrey, "but by combining resources with neighboring States they could increase their responsiveness to local industries and regulating agencies." At the same time, this would free NBS resources that can be used to develop new measurement techniques in response to new technologies and products in the marketplace.

"Personally, I am convinced," says McCoubrey, "that in the United States, our best opportunities for increased measurement quality on a national scale are to be found with the metrology laboratories of the States." *G L* □



"The cornucopia of small and subtle artifices is as ingenious, and in a deep sense as important in the ascent of man, as any apparatus of nuclear physics: the needle, the awl, the pot, the brazier, the spade, the nail, and the screw, the bellows, the string, the knot, the loom, the harness, the hook, the button, the shoe . . . ."—Jacob Bronowski, The Ascent of Man

Probing the past with neutrons

COVER STORY:

The picture on the front cover shows the blue glow radiated by rods of spent nuclear fuel from the research reactor at the National Bureau of Standards. This month's cover story illustrates only one of the many uses of that facility. See page 12 for a brief discussion of the reactor as a national resource.

by Gail Lupton

When an archaeologist stumbles across an artifact made thousands of years ago, the trail to its origin can be cold and hard to track. Yet, researchers are able to solve some of the mysteries of ancient civilizations with the aid of modern scientific methods.

At the National Bureau of Standards, for example, Geochemist James Blackman uses a research nuclear reactor to help him analyze the composition of certain clay and obsidian (volcanic glass) artifacts. He is looking for differences in the types and concentrations of elements present in small quantities. While major constituents of such materials remain essentially the same, minute differences in secondary elements occur with differing geological conditions.

Lupton is a DIMENSIONS staff writer.

With a technique called instrumental neutron activation analysis (see box), Blackman traces materials excavated from archaeological sites in the Middle East to their sources. This detective work can sometimes reveal knowledge about antiquity that literally lay buried for thousands of years. In particular, Blackman is interested in the commerce that existed between civilizations 5000 years ago.

A post-doctoral fellow of the Conservation Analytical Laboratory at the Smithsonian Institution, Blackman is a guest worker in the NBS Center for Analytical Chemistry. He is involved in the rather new field of archaeometry, which concerns both the conservation and analysis of archaeological items.

He is also one of about 50 researchers employed by organizations other than NBS who make use of the NBS research reactor and work with the Bureau's staff on a collaborative basis. The reactor was designed to serve the needs of government

The regions of volcanic activity in central Turkey (1) and eastern Turkey and Soviet Armenia (2) are the closest sources of obsidian to the archaeological sites of Tepe Yahya (3) and Tal-e Malyan (4) over 1000 kilometers away. Fragments of obsidian objects have been found at Tepe Yahya and Tal-e Malyan.

agencies and private organizations (see box).

Blackman came to NBS in 1976, after using several other techniques for determining elemental composition. He decided that, for his purposes, neutron activation analysis was the best method available. Right now, he is working with objects which were found at the archaeological sites of Tal-e Malyan and Tepe Yahya in present day Iran.

"I am mainly interested in the time period from 3500 B.C. to 1500 B.C.," says Blackman. No decipherable written records from the early part of this era, called the Proto-Elamite Period, have been recovered from these two sites, he says, so the archaeological record is particularly important.

Obsidian is a readily recognizable black material which occurs geologically only in the vicinity of certain types of volcanic activity. It is not native to either of these areas of Iran.

Although obsidian consists mostly of silicon and oxygen, Blackman distinguishes areas of geologic origin on the basis of differences in trace (less than .01 percent) and minor (from 0.1 to 1 percent) elements including barium, chromium, and cobalt as well as such rare earth elements as lanthanum, lutetium, and europium.

Blackman notes that volcanoes may have many obsidian flows which occurred tens of thousands of years apart; each may have characteristic trace and minor element concentrations.

Because the closest sources of obsidian to Malyan and Tepe Yahya are in Turkey and Soviet Armenia, over 1000 kilometers away, it is unlikely that artifacts of volcanic glass found at these sites were locally procured (see map). "If you find a piece of obsidian at Malyan—even if it is just a sliver—it must have been traded," concludes Blackman.

The question is, traded by whom? The procedure Blackman follows to solve that mystery is careful and complex.

First, 100-milligram samples of the artifacts, of geologic source materials, and of well characterizd standards, such as coal fly ash, are placed next to the core of the reactor and simultaneously irradiated with neutrons for eight hours. Some of these neutrons are "captured" by the nuclei of the atoms in the samples, creating unstable isotopes* which immediately begin to decay (emit energy).

The samples are stored for 14 days to decrease the total radioactivity of the materials. Then, with a germanium crystal detector, each sample is analyzed. The detector, with associated electronics, "counts" the number of gamma ray emissions at distinct energy levels and produces a corresponding spectrum of peaks that can be viewed on an oscilloscope screen.

Left. Because many of the objects he works with are very fragile, like the clay bead shown here, Blackman uses a small hand drill to extract samples for analysis.

Below. A "squeeze" of clay found at the archaeological site of Tal-e Malyan in present day Iran clearly shows the fingerprints of a craftsman who lived about 5000 years ago.

Although a proportion of all the elements in the materials become radioactive, Blackman explains that not all will be detected. A complex interaction between the weight of the sample, the concentration of the element present, the length of time irradiated, the flux of the reactor (that is, the number of neutrons the samples are exposed to), the time the material is allowed to decay before analysis, and the susceptibility of individual elements to neutron capture will determine which elements "you are able to see."

The challenge in neutron activation, he adds, is to "arrange things so you get the optimum set of circumstances for the elements you are interested in."

By matching peaks in the spectra of standards, which have known composition to peaks in the

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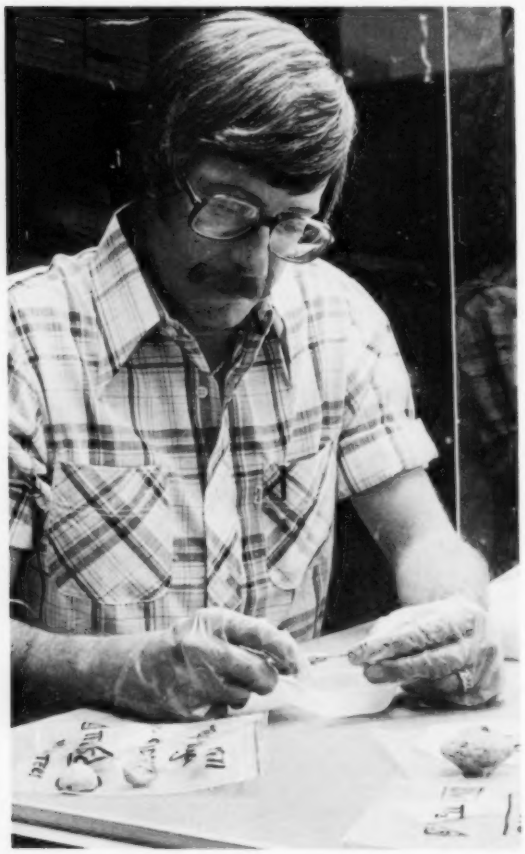
* Two or more species of the same chemical element which differ in the number of neutrons per nucleus.

spectra of artifact and geologic source material samples, Blackman determines element concentrations for these samples.

In this way, he can group the obsidian artifacts according to concentration profiles and in some cases match a particular profile to a specific volcanic source.

Blackman performs the same type of analysis to compare the clay of common objects such as buttons, beads, and tablet fragments with the clay of seal impressions.

"A seal impression on goods," says Blackman, "was similar to wax seals put on letters with signet ring at a later date." A trader would cover a ceramic vessel full of merchandise with an animal skin and tie it on with rope. Clay was then smeared over the rope as a seal and stamped with an identifying impression, "as a protection against getting ripped off in transit."



After Blackman takes a 100-mg sample of clay from an artifact, he puts it in a polyethylene container and irradiates it in the reactor for eight hours.

By looking at trace and minor element concentrations, Blackman compares the clay of seal impressions of unknown origin with items that were, according to the excavators, "almost certainly manufactured in the same area where they were found."

However, he says clays are much more complex than obsidians because there are so many possible sources and because clays were often mixed together or with rock fragments, which would alter trace element concentrations.

Blackman has been collecting clay samples from a number of regions in Iran. He plans to classify types by region and compare this data with an analysis of seal impression clay found at archaeological sites. "A seal impression made of clay radically different from the clay of that region was probably brought in by a trader," he says.

So far, Blackman has been able to determine that the obsidian artifacts he has from Malyan are from seven different sources. Two of these sources are at the volcanoes of Nemrut Daĝ and Zarnaki Tepe in the Lake Van area of eastern Turkey and a third source is in Soviet Armenia near Razdan. Four other sources remain unknown.

His obsidian artifacts from Tepe Yahya are all from either Zarnaki Tepe or Nemrut Daĝ.

"Once you know the source of the raw material," continues Blackman, "you have some idea of what areas were in contact with each other, and you can compare time periods to see if you can detect a change in the organization of trade."

For example, he says, early Malyan obsidian artifacts are almost all from one geologic source. During later periods, seven sources were about equally represented.

The isolated nature of volcanic sources makes obsidian an excellent indicator of trade, and Blackman's research complements work which has already been done to identify archaeological Middle Eastern obsidian.

Identifying clays by regions, though, is an enormous task, and Blackman says, "I've just barely scratched the surface." □

Neutron Activation Analysis

Instrumental neutron activation analysis is a method for simultaneously determining the types and concentrations of chemical elements within a sample of material. The idea of irradiating a compound with neutrons to identify its constituents was first suggested in 1936. The technique has increased in use since the 1950's because of the growth in the availability of research reactors.

The National Bureau of Standards has a 10 megawatt research reactor which uses enriched uranium 235 for fuel. The nuclei of the uranium in the reactor core undergo fissioning, which splits each nucleus into two parts. In the process, two to three neutrons are given off at high energy. These fast moving neutrons are moderated or "slowed down" by heavy water (deuterium oxide or D_2O) which surrounds the core of uranium fuel rods.

A sample to be irradiated near the fissioning fuel is sent into the reactor through one of four pneumatic tubes. Two of these deliver a sample within the core and thus receive a high percentage of fast or epithermal neutrons. The other two are further from the fuel and receive mostly slowed down or thermal neutrons.

Samples prepared for irradiation are individually packaged and placed in a polyethylene container called a "rabbit." The rabbit is then transported through one of the pneumatic tubes. (The container "leaps" quickly up the tube, which possibly accounts for its name.)

While the rabbit is in or near the core of the reactor, the samples and standards are bombarded with neutrons from the fissioning process. Some of these neutrons are "captured" by the nuclei of the elements, creating radioactive isotopes. The nuclei of these isotopes begin to decay at constant rates by emitting electromagnetic radiation of specific energies. Because each isotope has its own characteristic emission, it is possible to distinguish one from another. For this purpose, NBS uses lithium-doped germanium crystal detectors.

In a project now underway at NBS to identify trace elements in archaeological artifacts, neutron activation analysis works like this:

One hundred-milligram samples of artifacts, of similar material taken from known geologic sources, and of standard materials of known composition are irradiated together in the reactor.

A single irradiated sample is placed near a detector which has been isolated from external radiation. The detector is part of a d-c electrical circuit, and a potential difference is maintained across the germanium crystal.

As a gamma ray released by a decaying isotope in the sample passes into the crystal, it collides with atoms, dislodging electrons, until its energy is spent. A freed electron and the atom from which it has been liberated constitute an ion pair—a negative and a positive electric charge. The ion pairs formed by a single gamma ray are collected by the electrical circuit and result in a voltage signal which is proportional to the energy of the gamma ray.

An instrument called a pulse-height analyzer electronically records the voltage (energy level) of each signal (gamma ray). The collected information can be displayed on an oscilloscope or printed out digitally.

When displayed, the result is a series (spectrum) of peaks representing the number of gamma ray emissions that occurred at given energy levels. When peaks from an artifact sample match peaks produced by a standard material, precise element concentrations can be determined for the artifact.

Ultimately, the researcher conducting these analyses wants to find out where the objects originated. To link an artifact to a geologic source is to answer the question of the origin of the raw material. This happens when the spectrum of an artifact sample matches that of a geologic source material.

Neutron activation analysis is a sensitive research tool, but as with a sensitive, but not highly selective radio, there can be problems with background "noise." The researcher has to discriminate between relevant signals produced by gamma rays and interference—not an easy task.

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NBS Reactor—A National Resource

The 10 megawatt nuclear reactor located at the National Bureau of Standards was designed and built to serve the research requirements of the whole Washington, D.C./Mid-Atlantic scientific community. Back in the mid-sixties, scientists from a number of different laboratories helped demonstrate to Congress that there was a "major need" for a sophisticated research reactor on a continuing basis, explains Robert S. Carter, chief of the NBS Reactor Radiation Division.

Thus, from the time funds were appropriated to the present, the NBS facility has been intended to serve not only the Bureau, but also many other government agencies, industrial laboratories, and universities.

There are currently about 50 researchers from outside organizations working directly with NBS personnel on problems as diverse as the study of the lifetime of heart pacemaker batteries and the molecular structure of new materials for Navy sonar transducers. Although organizations which have collaborative arrangements with NBS do not pay for the operation of the reactor itself, they do contribute substantially to the purchase and maintenance of experimental instrumentation.

Input from these outside organizations, representing a broad spectrum of interests, has made it possible to develop more than 25 major experimental facilities ranging from complex neutron spectrometers to extensive irradiation capabilities. Consequently, NBS has a very versatile reactor with a greater diversity of programs than any other research reactor in the country.

In addition to direct collaboration, NBS also provides irradiation services and measurements to outside organizations—whether they are analyzing moon rocks or measuring the concentration of toxic elements in food. Service contracts include a charge for the neutrons used and the time spent by NBS personnel.

In either case, a service or collaborative tie, says Carter, "Each program is set up according to the needs of the requesting research organization."

Funding has been approved by Congress, and plans are now underway to double the power of the reactor to 20 megawatts. This will increase the productivity of the facility even more, says Carter. Doubling the power or neutron intensity means experiments can be done in half the time and more difficult projects can be undertaken.

For further information, call or write Carter at the National Bureau of Standards, Reactor Radiation Division, A106 Reactor Building, Washington, D.C. 20234, 301/921-2421.

As sophisticated as neutron activation analysis may be, it has many uses of both scientific and general interest. For example, a story in the September 9 edition of the *Washington Post* began with this sentence: "The House Assassinations Committee yesterday disclosed that new tests have matched fragments of metal from the wrist of former governor John Connally with the so-called 'magic bullet' from Lee Harvey Oswald's Mannlicher-Carcano rifle." The *Post* goes on to explain that this matching was achieved with neutron activation analysis.

No one method of chemical identification is suited for all purposes, but a number of complementary techniques exist and others are being developed. One powerful method with a legion of uses—x-ray powder diffraction—is discussed in the next story. Researchers at NBS have recently developed another diffraction method, this one involving neutrons instead of x-rays. It can identify large molecules of particular interest in health studies. The "New NBS-NIH Large-Molecule Diffractometer" is explained in the *Staff Reports* section of this issue.

Chemical fingerprints on file

by Juli Chappell

HOW do you solve what seems to be a hopeless case of mistaken identity? Dramatically, if you are Mark Twain, by astonishing your readers with a marvel of the most modern technology: two sets of matching fingerprints introduced into the heat of a courtroom battle.

Some marvels of 20th Century technology operate on this same basic principle. Like human fingerprints, chemical compounds have unique patterns. Although considerably less dramatic when applied by a scientist rather than a storyteller, very sophisticated techniques can determine these patterns and reveal the identity of a substance.

One such method, called x-ray powder diffraction, is involved in virtually any characterization of crystalline chemical materials. Applications range from matching paint specimens in hit-and-run automobile accidents to prospecting for oil by examining rock formations.

The technique consists of taking a small sample of an unknown material, usually in powder form, and exposing it to a beam of x rays. Because of the internal arrangement of the atoms in the tiny crystals, the beam is diffracted (deflected) in definite directions which relate to the internal structure of the material. An electronic counter can detect these diffracted beams and their relative intensities, or the beams can be recorded on photographic film. In either instance, the resulting patterns are converted to numbers that indicate the direction and intensity of the beams. Like human fingerprints, they are compared against a file of known patterns.

This Powder Diffraction File (PDF) is maintained and distributed by a non-profit organization known as the International Centre for Diffraction Data, located in Swarthmore, Pennsylvania. Some 30 000 crystalline materials are indexed in the PDF, and the file is continually being revised and improved for use worldwide by businesses and industries, universities, research laboratories, and law enforcement groups.

The National Bureau of Standards, with expertise in x-ray powder diffraction developed over the past 50 years, plays an active role in researching and improving this technique and in contributing to the efforts of the International Centre. Since 1951, the Centre (then known as the Joint Committee for Powder Diffraction Standards) has conducted a Research Associate Program at NBS,* and currently sponsors 6 Research Associates who work at the Bureau. This group produces patterns of high accu-

Dr. Stanley Block, chief of crystallography in the NBS National Measurement Laboratory, provides general direction for all x-ray diffraction work at the Bureau.

Chappell is editor of DIMENSIONS/NBS.

** Research Associate Programs have brought researchers from all areas of industry to NBS labs for over 50 years to work on projects of mutual interest and mutual benefit. For information contact P.R. de Bruyn, Administration A402, National Bureau of Standards, Washington, D.C. 20234, 301/921-3591.*

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Right. Chemist Simon Carmel of NBS works directly with the ICDD research associates in x-ray diffraction.

Below. Dr. Cambden Hubbard, an NBS research chemist, heads the Bureau's powder diffraction program.

racy which go into the PDL and are also published in Bureau monographs.*

"There are advantages for both sides in this affiliation," says Peter de Bruyn, NBS industrial liaison officer. "The ICDD has access to NBS personnel and instrumentation. The Bureau benefits from the data the group generates and from the opportunity to publish the results of the research."

"It is only natural that NBS should be directly involved in the use of a major form of chemical analysis," says Dr. Stanley Block, chief of crystallography in the NBS Ceramics, Glass, and Solid State Science Division. "Not only is this work of great practical value to companies all over the world, it is also applicable to much materials research done here at NBS," claims Block, who provides general direction for the x-ray diffraction work.

In short, NBS is mainly interested in fostering this research relationship because it advances an effective technique for scientific investigation. Powder diffraction is unique in its ability to determine not only the chemicals in a material—which many methods can do—but also to identify the crystal forms in which they occur. These two examples are among thousands that could be used to show why this kind of determination is important:

- The lung disease known as silicosis is caused by inhaling certain crystalline forms of the material known as silica. To protect workers in industry, it is necessary to know whether harmful forms are present in the air of mines or factories. X-ray powder diffraction is ideal for this purpose.
- A few years ago, manufacturers were having a problem with the durability of paint. Some batches, for some unknown reason, were much more durable than others. When samples were examined with x-ray diffraction, researchers discovered why this was so: Titanium dioxide, a compound widely used to make paint opaque, can have any of three crystal structures. The durability of the product varies depending on which of these structures is present. By using the form of titanium dioxide best suited for paint, manufacturers are better able to control quality.

"The use of x-ray diffraction is so widespread, I'd be surprised if it were not involved in every field requiring chemical analysis," says Andrew Danko, general manager for the International Centre. Danko points out that subfiles of the PDF have been published in various areas such as organic chemistry, metallurgy, and mineralogy.

Certainly x-ray powder diffraction is one among several techniques for chemical identification that are growing in importance and use. This growth can be attributed to increasing awareness in industry and government of the need for a solid base of chemical information. For example, a plan is now being worked out between the Environmental Protection Agency and the National Institutes of Health for a chemical information system. The system would include data about compounds from various forms of chemical study. In all likelihood, the Powder Diffraction File would be included intact. □

* *The latest such publication is NBS Monograph 25, Section 15, "Standard X-Ray Diffraction Powder Patterns," available through the Superintendent of Documents, Washington, D.C. 20402. Price $2.75, Stock No. 003-003-01842-2.*

Who's Who in the X-ray Diffraction RAP

Marlene Morris

Howard McMurdie

Eloise Evans

Johan de Groot

Boris Paretzkin

Mary Owen

The people who carry out the x-ray powder diffraction Research Associate Program (RAP) at the National Bureau of Standards are employees of the non-profit International Centre for Diffraction Data in Swarthmore, Pennsylvania. They serve as the research group for the ICDD and produce patterns of high accuracy for the Powder Diffraction File. Their parent organization is one of several private associations or industries that cooperate with NBS in research to benefit the public.

Theirs is the second oldest NBS Research Associateship, dating from 1951. (The American Dental Association has worked with the Bureau since 1928.)

The x-ray diffraction RAP is directed by Marlene Morris, a chemist, who serves as liaison between the research group, the main office of the ICDD, and NBS. Along with guiding and assisting in various areas of the work, she also produces experimental data. Morris has been with the group in various capacities for more than 23 years.

Howard McMurdie, a former long-time NBS researcher and manager in the area of powder diffraction, is now a part-time consultant with the Research Associate Program. In addition, he is one of the editors of the Powder Diffraction File, and in this capacity he reviews data from the general scientific literature in this field.

Eloise Evans, the mathematician of the group, provides expertise on the use of the computer and produces patterns mathematically from the results of detailed studies of the atomic arrangement of the crystalline phase.

Johan de Groot, the program's preparatory chemist, synthesizes and recrystallizes materials to be used for standard x-ray patterns. He constructs specialized equipment and makes chemical analyses when necessary.

Boris Paretzkin, a chemist, performs experimental work with particular emphasis on organic materials. To improve the crystallinity of these materials, recrystallization or other appropriate treatments may be performed.

Mary Owen provides clerical technical assistance, including assembly of computer runs.

The x-ray powder diffraction Research Associate Program is one of 23 RAP's at NBS. Of these, 13 are sponsored by trade and professional organizations such as ICDD, 8 by individual industrial companies, and 2 by U.S. Government agencies. A total of 80 research associates are involved in these programs. For information, write or call Peter de Bruyn, NBS Industrial Liaison Officer, Administration A402, NBS, Washington, D.C. 20234, 301/921-3591.

STAFF REPORTS

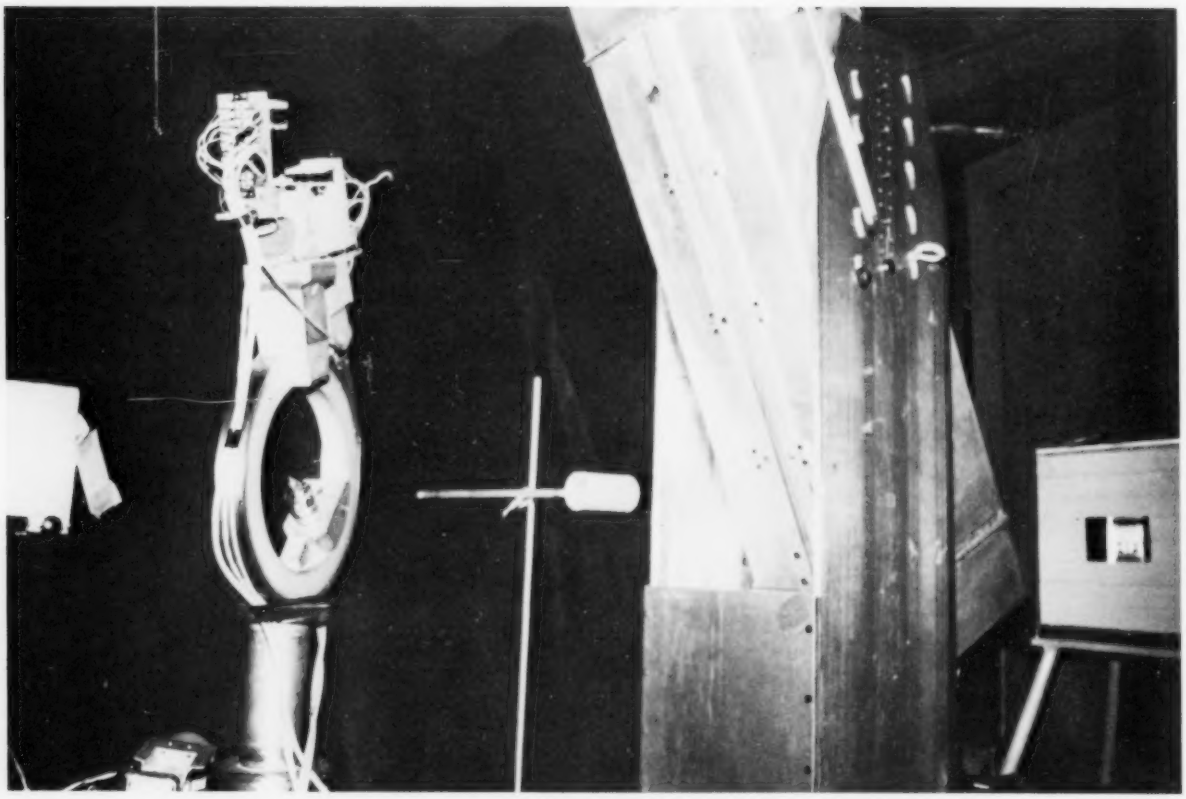

Figure 1—*Flat-cone neutron diffractometer utilizing a 1-m long area detector, installed at the National Bureau of Standards.*

NEW NBS-NIH LARGE-MOLECULE DIFFRACTOMETER

The intensity of emission from even high-flux neutron sources, such as the NBS reactor, is insufficient for fast collection of crystallographic data from macromolecules such as proteins. A new instrument called "flat-cone diffractometer" has been constructed and tested at the reactor, based on an advanced method proposed by reactor division scientists. It is equipped with a position-sensitive detector which allows simultaneous measurement of a number of reflections, thus speeding the data collection by a factor of ten, cutting the time needed to measure a data set from several months to one or two weeks.

*Alexander Wlodawer, Antonio Santoro, and Edward Prince, Reactor Radiation Division, A106 Reactor Building, 301/921-3634.**

Neutron diffraction from single crystals of biological macromolecules, such as proteins, can yield information which is

* *In collaboration with David Davies, Laboratory of Molecular Biology, National Institute of Arthritis, Metabolism, and Digestive Diseases, Bethesda, Maryland.*

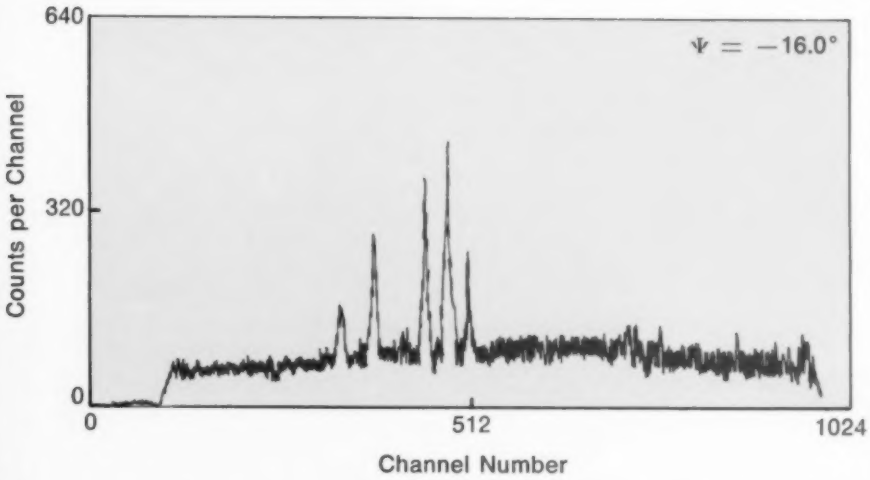

Figure 2—*Example of the output of the diffractometer during collection of data from a large single crystal of ribonuclease. Counting time 1 min. Several strong reflections are clearly visible; other weaker reflections are partially obscured by the background due to incoherent scattering.*

very difficult, if not impossible, to obtain by other methods, including the powerful technique of single-crystal x-ray diffraction. On the other hand, radiation flux from even the best thermal neutron sources is six orders of magnitude lower than that of x-ray tubes used in biological studies. For that reason, improvements in data collection techniques are necessary to utilize fully the power of neutron diffraction.

In collaboration with the Laboratory of Molecular Biology at the National Institutes of Health (NIH), we have developed an advanced method of collecting crystallographic data. A new type of neutron single crystal diffractometer has been constructed based on this method. It utilizes a 1-meter long position-sensitive detector set in flat-cone Weissenberg geometry to allow simultaneous collection of up to 10 diffraction peaks under computer control. This method greatly increases the rate and resolving power of crystallographic data collection of macromolecules.

Using the new facility and a high intensity neutron beam at the NBS Reactor, we have collected a preliminary data set for the structure determination of a digestive enzyme, ribonuclease. These neutron diffraction data are necessary to provide structural details related to hydrogen bonding of the protein chains and to evaluate the role of the water molecules which surround the protein molecules in the crystal much as they do in living material. This information is, in turn, critical to an understanding of the role of hydrogen bonds and water in the biochemical activity of enzymes. Several models of the atomic structure of ribonuclease based on x-ray diffraction data have been published in the last 10 years, but since x rays are incapable of distinguishing oxygen atoms from nitrogen and miss hydrogen atoms completely, these models are known to be ambiguous, thus making it difficult to explain the details of enzymatic activity. A new model based on neutron data may solve many of these ambiguities.

Our work in this area at the NBS reactor is one of only three such neutron diffraction efforts to study protein structures currently being carried out in the world. This new method and instrumentation can also be applied to the determination of the structure of other materials having very large crystalline unit cells.

STANDARD REFERENCE MATERIAL FOR ELECTRON EXPERIMENTS

The NBS Office of Standard Reference Materials announces the availability of a Standard Reference Material for use in Electron Paramagnetic Resonance (EPR) experiments. It was developed by the Ceramics, Glass, and Solid State Science Division of the Center for Materials Science.

Standard Reference Material 2601, synthetic ruby (i.e., $A1_2O_3$ containing Cr^{3+} ions), is designed to calibrate the intensities of EPR spectral lines to an accuracy of ±10 percent, or better. If sufficient information concerning the active spins of a test sample is known, and if certain conditions are met, the calibration can be used to give the total number of active spins in that test sample. Capability for performing double integrations of absorption curves by graphical or computer methods must be available to the user.

This SRM consists of two precisely oriented samples of annealed and etched ruby. One is a square plate of nominal size 1.5 × 1.5 × 0.5 mm; the second is a bar of nominal size 0.5 × 0.5 × 4.0 mm. The masses of the samples range between 1.9 and 3.6 mg. The concentration of Cr^{3+} ions is 3.69×10^{15} per mg. The mass of each sample in a set and the total number of Cr^{3+} ions in each sample are certified.

SRM 2601 may be ordered from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234. The price is $153 per unit.

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FIBROUS GLASS BOARD STANDARD REFERENCE MATERIAL

The NBS Office of Standard Reference Materials announces the availability of Standard Reference Material for thermal resistance at mean temperatures from 255 to 330 K.

Standard Reference Material 1450, Fibrous Glass Board, is certified on the basis of thermal resistance measurements made on the NBS 20-cm square guarded hotplate apparatus since 1958. The uncertainty in the certified thermal resistance is ±2 percent.

The material consists of fine-fibered glass formed into a semi-rigid board with phenolic binder. The bulk density ranges from 110 to 170 $kg \cdot m^{-3}$ (7 to 11 $lb \cdot ft^{-3}$). The material appears to be stable for a period of 20 years.

This SRM is useful for calibrating apparatus such as the guarded hot plate (ASTM C177) and heat flow meter (ASTM C518) used to determine the thermal resistance of thermal insulation materials. Periodic use will permit checking for changes in apparatus performance that may otherwise go unnoticed.

SRM 1450 is available as a 2.54-cm (1-in) thick semi-rigid board nominally 60 cm (2 ft) square. Smaller squares will be provided on an individual basis. Orders for this material should be placed with the Office of Standard Reference Materials, Room B311, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234. The price of SRM 1450 is $302.

Figure 1—*Photograph showing the stylus instrument and operator's console in the foreground with the minicomputer and its peripherals in the background.*

FAST FACILITY AVAILABLE FOR ENGINEERING NEEDS

Researchers at the National Bureau of Standards have developed a new facility for analyzing the microtopography of surfaces. The need for studying surface texture is increasing in a number of engineering applications from ship building to satellite communications. The automated NBS system provides industrial users with measurements of important parameters and functions which are not routinely available elsewhere in the United States.

Theodore V. Vorburger, E. Clayton Teague, and Fredric E. Scire, Mechanical Processes Division, A123 Metrology Building, 301/921-3838.

Traditionally, the concept of surface roughness has been used in the study of friction, lubrication, and wear of mechanical devices. Many parts of a new automobile, for example, require specification and measurement of surface roughness to insure that the final product will perform properly. Nowadays, however, people in such diverse technologies as ship building, high-power lasers, computer discs, and satellite communications are discovering that they also need to study the surface microtopography of the components they work with.

At NBS for example, we have been working with the U.S. Navy on a program to relate the textures of marine paints to the drag of ships. The potential savings in fuel consumption for very smooth ship hulls could be enormous. In a very different area, the quality of signals relayed from communications satellites depends on the topography of sliding contacts in the satellites. We are cooperating in the Air Force's program to explore this problem.

The growth of interest in measuring surface texture has led people to try to understand better the influence of surface topography on the performance of their devices.* Whereas traditionally engineers have relied almost solely on a parameter known as the average roughness to describe the quality of their surfaces, other parameters or functions are now found to be more important for various applications. For example, the scattering of laser light from an optical surface depends very much on a statistical function of the surface topography known as the "power spectral density" (the name comes by analogy from a similar concept in spectroradiometry and communications engineering).

We have recently developed a new Facility for Analyzing Surface Texture (FAST) to meet these conventional and developing needs for surface measurement in industry. The system can do traditional calibrations of the average roughness of surface artifacts and can measure the more complex statistical parameters for detailed analysis of surface texture. The present facility represents the latest development in NBS' ongoing program for automated surface-texture characterization.**

FAST, as pictured in Figure 1, consists of a minicomputer, new NBS computer programs, and a high quality, commercial, surface-measuring instrument. Figure 2 shows schematically how the system works. The instrument uses a diamond stylus with a transducer which detects the undulations of a surface and produces an electrical current proportional to the height of the surface segment contacting the stylus. The stream of electrical signals that results when the stylus is drawn over the surface is fed to the minicomputer after an analog-to-digital conversion.

The result is a profile of the surface which is stored in the computer as 4000 digitized numbers. The points on the profile which are sampled and stored by the computer are also shown schematically. The data transfer rates are very fast so that a 4000-point array of 4-digit numbers representing a 4-mm long profile can be collected in about 2½ seconds. In Figure 2, the stylus is shown traversing a highly perfect sinusoidal surface. This is a prototype for a set of such surfaces which are being developed jointly by NBS and Lawrence Livermore Laboratory for distribution as surface texture Standard Reference Materials (SRM's). The final SRM's will be used in an international round-robin of laboratories, which is being organized by NBS and our counterparts in Australia.

Examples of typical data and analysis done with the new system are shown in Figure 3. Curve (a) shows the power spectral density function (PSD) which the minicomputer has calculated for the sinusoidal surface. It is only one example of a statistical function which can be generated by the computer from the profile data. The PSD shows how the surface profile can be broken down into its component wavelengths. Since a perfect sinusoidal profile consists of a single wavelength λ, the PSD should be a single spike located at that wavelength. Accordingly, Figure 3a shows a large spike located at $\lambda = 100\ \mu m$ with only tiny contributions from higher harmonics at 50, 33,

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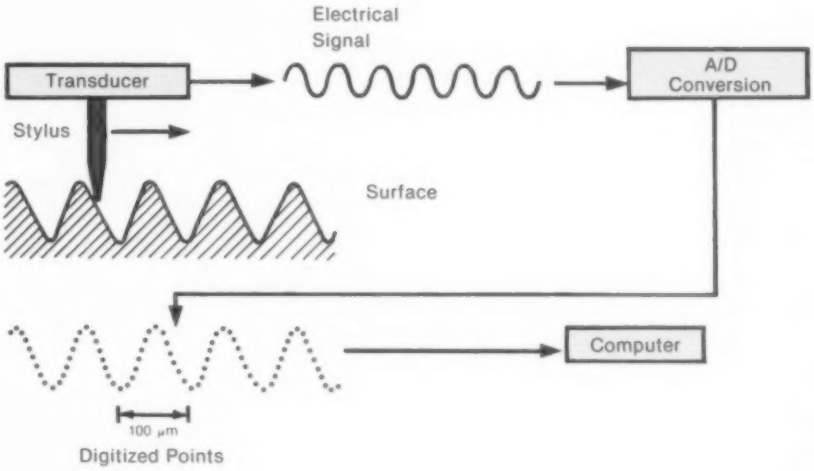
Figure 2—*Schematic diagram showing FAST in operation with the stylus traversing a sinusoidal surface currently being tested as a prototype surface roughness SRM.*



* *Whitehouse, D. J., 1971. Typology of Manufactured Surfaces, CIRP Annals, 19, 417-431.*

** *Swyt, D. A., 1973. A System for Computerized Surface Roughness Measurement, NBSIR 73-106. Teague, E. C., 1976. Evaluation, Revision, and Application of the NBS Stylus/Computer System for the Measurement of Surface Roughness, NBS Tech. Note 902.*

and 20 μm. The PSD, therefore, clearly shows that the surface is indeed nearly sinusoidal, and in this situation it is a valuable function for ascertaining the perfection of our prototype SRM's. The data of Figures 2 and 3a may be compared with those for a more random surface shown in 3b and c. The profile (b) was taken from a roughness comparison specimen used for testing machined parts with ground surfaces. Its profile waveform is quite random. As a result, the PSD (c) reveals a wide range of wavelength components on the surface. Our measurements on the comparison specimen are part of a preliminary study to relate certain aspects of light scattering from a rough surface to the appropriate topographic parameters of the surface.

FAST's programs involve a high degree of interaction between the operator and the computer so that an operator who is not skilled with computers can be guided through a complex series of surface measurements. With the greater memory capacity of the new system, surface data can be rapidly stored and accessed at a later date for further analysis. The memory and software of the new system enable one to calculate on-line a number of surface statistical parameters which are described in the American National Standard *** for surface texture, but which are not routinely available anywhere else in the United States.

*** *American National Standards Institute B46.1, 1978. Surface Texture (The American Society of Mechanical Engineers, New York.)*

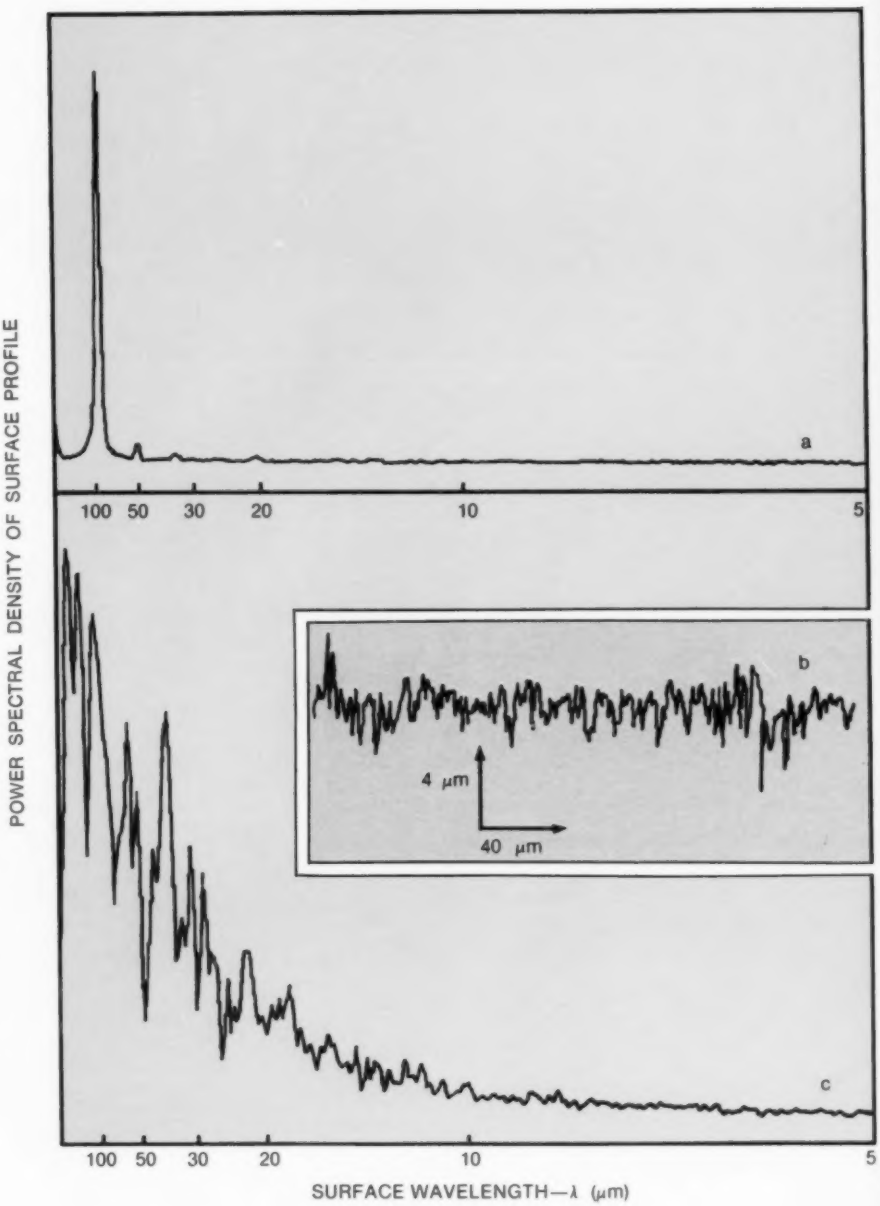


Figure 3—*(a) Power Spectral Density of the sinusoidal surface shown in Figure 2. (b) Profile of a surface roughness comparison specimen for ground surfaces. (c) Power Spectral Density of the above comparison specimen.*

CONFERENCES

For general information on NBS conferences, contact JoAnn Lorden, NBS Public Information Division, Washington, D.C. 20234, 301/921-2721.

INTERNATIONAL SYMPOSIUM ON STONE DEGRADATION

The proceedings of a recent international symposium on the degradation and protection of stone monuments are now available. Organized by CEBTP under the direction of UNESCO and RILEM, the meeting was held in Paris from June 5-9, 1978.

The symposium was designed to inform architects, conservators, restorers, and building specialists of the state-of-the-art in evaluating damage to materials and in measuring the efficiency of methods for treating stone monuments and works of art.

More than 200 people, representing 27 nations, participated in the meeting. The themes addressed in the 74 symposium papers include: the degradation of monuments, determination of the degree of stone degradation, degradation and treatments based on biological studies, degradation and treatments based on petrographic studies, studies of products and methods of treatment, and restoration of monuments.

The proceedings of the symposium are available from CEBTP, Service d'Etude des Materiaux, Domaine de Saint-Paul, 78470 St Remy-les-Chevreuse, France. The price of 350 FF (approximately $77) includes taxes and shipping.

ENERGY CONSERVATION THROUGH MORE EFFICIENT ROOFING SYSTEMS

Thermally efficient roofing systems is the general theme of the Fifth Roofing Technology Conference to be held April 19-20, 1979 at the National Bureau of Standards in Gaithersburg, Maryland. The conference is cosponsored by NBS and the National Roofing Contractors Association (NRCA).

The two-day meeting is the first national conference devoted exclusively to energy conservation in industrial and commercial roofing systems. The conference will focus on the problems of designing and installing energy-efficient roofing assemblies. Among the subjects to be discussed at the meeting are moisture effects in insulation, methods for inspecting an existing roof to determine its thermal effectiveness, procedures for upgrading thermal efficiency, and membrane performance considerations with respect to thermal efficiency.

The meeting is expected to be attended by architects, engineers, building contractors, product manufacturers, and government and academic researchers. Conference speakers have been drawn from research institutions, roof construction companies, material manufacturers, and engineering firms.

Additional information about the meeting may be obtained from either Robert Mathey, B348 Building Research Building, 301/921-3407, NBS, Washington, D.C. 20234, or from Gary Van Ryzin, National Roofing Contractors Association, 1515 N. Harlem Avenue, Oak Park, Illinois 60302.

CONFERENCE CALENDAR

December 18-20
WORKSHOP ON SOFTWARE TESTING AND TEST DOCUMENTATION, Bahia Mar Hotel, Ft. Lauderdale, FL; sponsored by NBS and IEEE Computer Society; contact: Edward E. Miller, Software Research Associates, P.O. Box 2342, San Francisco, CA 94126, 415/921-1155 or 415/957-1441.

1979

April 2-4
TEMPERATURE COMPENSATION IN THE MEASUREMENT OF PETROLEUM PRODUCTS, NBS, Gaithersburg, MD; sponsored by NBS and NCWM; contact: Harold Wollin, A211 Metrology Building, 301/921-3677.

April 3-5
SYMPOSIUM ON BUILDING SECURITY, NBS, Gaithersburg, MD; sponsored by NBS and ASTM; contact: John Stroik, A355 Building Research Building, 301/921-2107.

***April 16-18**
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry Burnett, B264 Materials Building, 301/921-2813.

April 19-20
5TH ROOFING TECHNOLOGY CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and NRCA; contact: Robert G. Mathey, B348 Building Research Building, 301/921-3407.

May 17
TRENDS AND APPLICATIONS SYMPOSIUM, NBS Gaithersburg, MD; sponsored by NBS and IEEE; contact: Shirley Watkins, B212 Technology Building, 301/921-2601.

***May 21-22**
WORKSHOP ON THERMAL ANALYSIS, NBS, Gaithersburg, MD; sponsored by NBS and the University of Akron; contact: Oscar Menis, B326 Chemistry Building, 301/921-2175.

June 11-15
SYMPOSIUM ON ACCURACY IN POWDER DIFFRACTION, NBS, Gaithersburg, MD; sponsored by NBS, National Research Council of Canada, and the International Union of Crystallography; contact: Stanley Block, A219 Materials Building, 301/921-2837.

*New Listings

PUBLICATIONS

TEACHER AIDS

by Stan Lichtenstein

The following materials produced by agencies of the federal government are recommended by DIMENSIONS/NBS for their potential value to educators as supplements to the classroom or school library.

Productivity and Technological Innovation: Selected Information Sources

The quantity and quality of what America produces are affected by many economic, social, mechanical, and psychological factors. This quickly scanned 12-page brochure lists useful items under appropriate headings. Some of the entries are concerned with the roles of precise measurement, computers and automation, and specific industry and product system technologies (food, railroads, pharmaceuticals, canning, communications, others). Free. Available from:
U.S. Department of Commerce
Industry and Trade Administration
Washington, D.C. 20230

Selected Department of Energy Publications

A 14-page roundup of the Department's general interest and educational publications on numerous aspects of the energy problem. Free. Available from:
Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

Jet Roar

A 14-minute, 16-mm color film produced by the Environmental Protection Agency in 1977, addressing the airplane/airport excessive noise problem from a "poor land use and faulty construction practices," as well as engineering, point of view. The film champions effective community action against irritants caused by aircraft. Purchase price: $81.25. For free loan, contact:
Modern Talking Pictures
Central Distribution Office
2323 New Hyde Park Road
New Hyde Park, NY 11040

The Ultrasonic Thermometer

A 4-minute, 16-mm sound/color film showing how NBS developed an instrument making possible an acceptable scientific temperature scale in the 4 to 14 kelvin range. The ultrasonic thermometer measures the length of sound waves in helium gas. The speed of these waves is a function of their length; accordingly, gas temperature can be computed from that speed and the operating frequency. The film's presentation is keyed to audiences of working scientists, college science students, and special science students in high school. Available on free loan from:
Association Films
600 Grand Avenue
Ridgefield, NJ 07657
For purchase information, contact:
Public Information Division
National Bureau of Standards
Room A640, Administration
Washington, D.C. 20234
Phone: 301/921-3112

Edge of Discovery

A 28-minute, 16-mm color film produced in 1975. Looks at the ancient problem of marine fouling in the light of new, Navy-developed, preventive methods. Film shows effects of barnacles and other fouling growths on metals and materials, and tells what can be done. Purchase price, $162.50. For free loan, contact:
Naval Education and Training Support Center
Atlantic Building W313
Fleet Branch Naval Station
Norfolk, Virginia 23511

The Force and Control of Surface Tension in the Lung

A slide set (61 color slides, 71-minute audiocassette) produced by the National Medical Audiovisual Center. Surface tension affects the lungs during inspiration and expiration. The slide set details the physiological process, explains collapsing forces in alveolae, and shows how a surface-active agent may combat and regulate these forces. For information (Title No. 009487/HH), contact:
National Audiovisual Center
National Archives and Records Service
General Services Administration
Reference Section HH
Washington, D.C. 20409
Phone: 301/763-1896

FIGURING COSTS OF THE POLICE PATROL CAR

*The Police Patrol Car: Economic Efficiency in Acquisition, Operation, and Disposition, Ruegg, R. T., Nat. Bur. Stand. (U.S.), Spec. Publ. 480-15, 117 pages (Apr. 1978) Stock No. 003-003-01837-6, $3.**

There are many different choices to be made with respect to police vehicle acquisition, utilization, maintenance, and disposition. Cost comparison among the different alternatives is an important element in the choices to be made. To make valid cost comparisons, it is necessary to employ the techniques of life cycle costing. This means the inclusion of first and end costs, and operation and maintenance costs, as well as the conversion of costs to an equivalent basis to take into account differences in the timing of expenditures.

This report uses life cycle costing techniques to examine the costs of some of the alternative approaches to patrol car acquisition, operation, maintenance, and disposition. Although the great variability among departments makes it inadvisable to think in terms of uniform fleet management rules, the findings of this study are expressed as general guidelines where

Lichtenstein is a writer and public information specialist in the Public Information Division.

appropriate. The analytical methods used in the cost comparisons are described, illustrated and recommended as useful decision tools for fleet managers. In addition, a descriptive overview of existing police fleet practices is provided in a number of tables on fleet composition, patrol car selection and accessorization, car utilization practices, maintenance, and replacement policy.

Specific questions addressed by the study are the following:

1) What are the cost effects of purchasing different sizes of patrol cars and different optional equipment?

2) What are the advantages and disadvantages of direct ownership of vehicles as compared to leasing vehicles?

3) How do the costs of contracting-out maintenance compare with the costs of an in-house shop?

4) what are the effects of alternative utilization practices on fleet costs?

5) How often should vehicles be replaced?

6) What method of vehicle disposition is most efficient?

The techniques used to compare costs of alternative systems are described in a chapter on life cycle costing methodology. Cost estimates and empirical data are presented in the many tables, exhibits, and charts which support the study. Existing fleet practices are described.

The focus of the study is on patrol cars, by far the predominant kind of vehicle in most police fleets. The methods and techniques are, however, applicable to other types of vehicles.

Building Technology

Gandemer, J., Building Research Translation—Discomfort Due to Wind Near Buildings: Aerodynamic Concepts, Nat. Bur. Stand. (U.S.), Tech. Note 710-9, 48 pages (Mar. 1978) Stock No. 003-003-01898-8, $1.60.

Computer Science and Technology

Cotton, I. W., Ed., Computer Science and Technology: Local Area Networking. Report of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, Aug. 22-23, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-31, 82 pages (Apr. 1978) Stock No. 003-003-01918-6, $2.40.

Saltman, R. G., Computer Science and Technology: Effective Use of Computing Technology in Vote-Tallying, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-30, 142 pages (Apr. 1978) Stock No. 003-003-01915-1, $3.

Wolcott, N. M., Computer Science and Technology: FORTRAN IV Enhanced Character Graphics, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-32, 57 pages (Apr. 1978) Stock No. 003-003-01921-6, $2.30.

Health and Safety

Fisher, R. L., Toth, D. D., Blomquist, D. S., and Forrer, J. S., The Development and Testing of a Highly Directional Dual-Mode Electronic Siren, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-28, 51 pages (Feb. 1978) Stock No. 003-003-01925-9, $220.

Welson and Co., Survey of Clothing Requirements for Uniformed Law Enforcement Officers, Nat. Bur. Stand. (U.S.), Spec Publ. 480-29, 22 pages (Apr. 1978) Stock No. 003-003-01919-4, $1.10.

Energy Conservation and Production

Trechsel, H. R., Energy-Effective Windows. Proceedings of a Joint DOE (ERDA/NBS Conference/Round Table on Energy-Effective Windows held in Washington, DC, Apr. 13, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 512, 53 pages (Apr. 1978) Stock No. 003-003-01929-1, $2.20.

Fire Research

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NEWS BRIEFS

CALL FOR PAPERS. Papers are now being solicited for the Fourth International Symposium on Ultrasonic Imaging and Tissue Characterization to be held at NBS, Gaithersburg, Md., June 18-20, 1979. The purpose of the symposium is to give doctors, engineers, physical scientists, and mathematicians an opportunity to discuss the current state-of-the-art, new directions of technology, and research opportunities in this developing area of medical diagnosis. Contact Dr. Melvin Linzer, A366 Materials Building, NBS, Wash., D.C. 20234.

CLARKE APPOINTED CENTER CHIEF. Dr. Frederic B. Clarke has been appointed director of the NBS Center for Fire Research. Formerly the Center's deputy director, Clarke has been acting director since January 1978, succeeding Dr. John Lyons, who now heads the Bureau's National Engineering Laboratory. The Center for Fire Research was established by the Federal Fire Prevention and Control Act of 1974 and is the principal Federal fire laboratory.

FREE FILMS FROM NBS. NBS has published a new catalogue listing over 30 films on a variety of technical problems and applications. All films are 16-mm color/sound and are available on loan to scientific and professional organizations. Each film description includes a notation indicating the intended audience and ordering information. Single copies of the catalogue may be obtained free from: Technical Information and Publications Division, A617 Administration Building, NBS, Wash., D.C. 20234; phone: 301/921-2318.

INTERNATIONAL COUNCIL NAMED. The American Society for Metals (ASM) and NBS recently established an international council of leading materials scientists, engineers, and educators to monitor an ASM-NBS program to assimilate, collate, and compile alloy phase diagrams. The council will assist ASM and NBS in planning, implementing, and evaluating this cooperative program, which is aimed at providing the international scientific community with compilations of evaluated phase diagrams and related bibliographic services.

TWO PRECISION MEASUREMENT GRANTS AVAILABLE. NBS is offering two Precision Measurement Grants for the year beginning October 1, 1979. The awards of $25 000 each will go to scientists in academic institutions for work in the field of precision measurements and the determination of fundamental physical constants. Prospective candidates must submit summaries of their proposed projects and biographical information to NBS by February 15, 1979, to be considered for these grants, which run from October 1, 1979, through September 1980. Contact Dr. Barry N. Taylor, B258 Metrology Building, NBS, Wash., D.C. 20234, or call 301/921-2701.

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